# Titanium Nanocomposite: Lightweight Multifunction Structural Material (TiMMnC)

Completed Technology Project (2015 - 2016)

## Project Introduction

We propose to research and develop lightweight metal matrix nanocomposites (MMnC) using a Titanium (Ti) metal matrix. Ti MMnC will crosscut the advancement of both science and structure to facilitate architecture and systems for long duration human extraterrestrial exploration. A Ti MMnC have the potential for greater than 20% mass reduction with improved radiation shielding and mechanical properties and serve the immediate need for lightweight multifunctional structural materials that are stronger and more reliable than the current state of the art (SoA).

In support of NASA's Technology Roadmaps TA 10 and 12, we propose to research and develop lightweight metal matrix nanocomposite (MMnC) using Titanium (Ti). Ti MMnC will crosscut the advancement of both science and structure to facilitate architecture and systems for long duration human extraterrestrial exploration. Ti MMnC have the potential for greater than 20% mass reduction and serve the immediate need for lightweight multifunctional structural materials that are stronger and more reliable than the current state of the art (SoA). The SoA for high specific strength metals is titanium and its alloys; such as Ti-6Al-4V (density of 443 kg/m3). Ti MMnC can be multifunctional materials that outperform SoA titanium alloys. Researchers have tried to make composites of titanium and carbon nanotubes (CNTs). The previous work demonstrated that the addition of CNTs can improve mechanical and hardness properties of titanium. However, CNTs react with the metal to form titanium-carbide during high temperature pressing, which is believed to increase the hardness and strength but reduce the ductility of titanium. Nanoparticles with the advantage of a higher thermal stability can endure the high temperature processing within the titanium without property reduction. We propose to fabricate Ti MMnC with thermally and chemically stable nanoparticles.

In this work, computational modeling will be utilized to identify a nanoparticle with high temperature and chemical stability that also has a strong interaction with the titanium metal matrix. Based on these computational efforts, composites will then be designed and fabricated.

## Anticipated Benefits

Ti-MMnC will benefit humans traveling to Mars. A material with greater than 20% mass reduction with improved radiation shielding and mechanical properties serves the immediate need for lightweight multifunctional structural materials that are stronger and more reliable than the current state of the art (SoA).

Ti-MMnC will benefit long term space travel beyond low earth orbit, as well as providing advanced materials for better engineered radiation shielding and thermal management.


Titanium Nanocomposite: Lightweight Multifunction Structural Material

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## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Center / Facility:**

Langley Research Center (LaRC)

**Responsible Program:**

Center Innovation Fund: LaRC CIF

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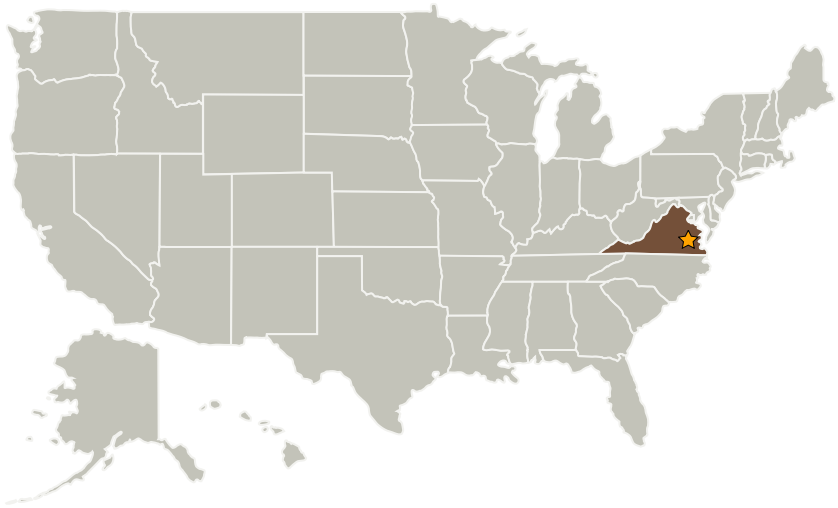
Structural components with a 20% mass savings at competitive manufacturing costs would enable more efficient space travel.

Other government agencies could utilize stronger, lighter, and more efficient vehicles using titanium metal matrix nanocomposites.

### Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| ★Langley Research Center(LaRC) | Lead Organization | NASA Center | Hampton, Virginia |

| Primary U.S. Work Locations |
|---|
| Virginia |

## Project Management

**Program Director:**
Michael R Lapointe

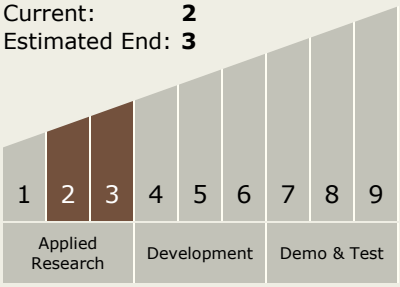
**Program Manager:**
Julie A Williams-byrd

**Principal Investigator:**
John-andrew S Hocker

**Co-Investigators:**
Cheol Park
Catharine C Fay
Vesselin I Yamakov
John A Newman
Sang-hyon Chu

## Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**




## Technology Areas

**Primary:**

- TX02 Flight Computing and Avionics
  - TX02.3 Avionics Tools, Models, and Analysis

*Continued on following page.*

## Technology Areas *(cont.)*

- TX02.3.4 Electromagnetic Environment Effects